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THE CONSTITUTION OF THE EARTH[1]

WHEN one is confronted as on this occasion with the British Association in plenary session it is permissible, I hope, to indulge in a few reflections on the nature and purpose of science in general. The theme is no new one and has never been discussed so frequently as in our time, but the very range of our activities entitles us to consider it from our own point of view. The subjects treated at these meetings range, according to the titles of our sections, from the most abstract points of mathematical philosophy to the processes of agriculture. Between these limits we have the newest speculations of astronomy and physics, the whole field of the biological sciences, the problems of engineering, not to speak of other matters equally diverse. These subjects, again, have become so subdivided and specialized that workers in adjacent fields have often a difficulty in appreciating each other's ideas, or even understanding each other's language. What then is the real purpose of science in the comprehensive sense, what is the common inspiration, the common ambition behind such enthusiastic and sustained effort in so many directions? The question may seem idle, for a sort of official answer has often been given. It was deemed sufficient to point to the material gains, the enlarged powers, which have come to us through science, and have so transformed the external part of our lives. The general aim was summed up in an almost consecrated formula: "to subdue the forces of nature to the service of man." And since it was impossible to foresee what abstract research might or might not provide a clue to something useful, the more speculative branches of science were not only to be tolerated, but to be encouraged within limits, as ancillary to the supreme end. And, it must be said, the cultivators of these more abstruse sciences have themselves been willing sometimes to accept this position. The apologists of pure mathematics, for instance, have been wont to appeal to the case of the conic sections, which from the time of Apollonius onwards had been an entirely detached study, but was destined after some 2,000 years to guide Kepler and Newton in formulating the laws of the planetary motions, and so ultimately to find its justification in the Nautical Almanac. I will not stop to examine this illustration, which I personally think rather strained. We may recognize that practical utility has been a

[1] Address of the president of the British Association for the Advancement of Science, Southampton, 1925.

conscious though not the sole aim in much scientific work, and sometimes perhaps its main justification; but we can hardly admit that any such formula as I have quoted worthily conveys what has been the real inspiration of discovery through the ages. If we may go back to Apollonius and the conic sections, we can not suppose that he was thinking of posterity at all; he was engaged in a study which he no doubt held to be legitimate and respectable in itself. Or, to take a very recent instance, when Faraday and Maxwell were feeling their way towards an electric theory of light, they could hardly have dreamed of wireless telegraphy, though as we now know this was no remote development. The primary aim of science as we understand it is to explore the facts of nature, to ascertain their mutual relations, and to arrange them as far as possible into a consistent and intelligible scheme. It is this endeavor which is the true inspiration of scientific work, as success in it is the appropriate reward. The material effects come later if at all, and often by a very indirect path. We may, I think, claim for this constructive task something of an esthetic character. The provinces of art and science are often held to be alien and even antagonistic, but in the higher processes of scientific thought it is often possible to trace an affinity. The mathematician at all events is at no loss for illustrations of this artistic faculty. A well-ordered piece of algebraical analysis has sometimes been compared to a musical composition. This may seem fantastic to those whose only impression is that of a mass of curious symbols, but these bear no more resemblance to the ideas which lie behind them than the equally weird notation of a symphony bears to the sounds which it connotes or the emotions which these evoke. And it is no misplaced analogy which has led enthusiasts to speak of the poetical charm of Lagrange's work, of the massive architecture of Gauss's memoirs, of the classic perfection of Maxwell's expositions. The devotees of other sciences will be at no loss for similar illustrations. Is it not the case, for instance, that the wide-spread interest excited by the latest achievements of physical science is due not to the hope of future profit, though this will doubtless come, but to the intrinsic beauty as well as the novelty of the visions which they unfold?

It is possible, I trust, to insist on these aspects of the scientific temperament without wishing to draw a sharp and even mischievous antithesis between pure and applied science. Not to speak of the enormous importance in our present civilization of the material advantages which have come in the train of discovery, it would be disloyal to science itself to affect to depreciate them. For the most severely utilitarian result comes often as the result of a long and patient process of study and experiment, conducted on strictly scientific methods. We must recognize also the debts which pure science in its turn owes to industry, the impulse derived from the suggestion of new problems, and not least the extended scale on which experiment becomes possible. And a reference may appropriately be made here to the National Physical Laboratory, initiated mainly in the higher interests of industry, which by the mere pressure of the matters submitted to it is becoming a great institute of theoretical as well as applied science, informed throughout by the true spirit of research.

But perhaps the most momentous consequences of the increased scientific activities of our time have been on the intellectual side. How profound these have been in one direction we have recently been reminded by the centenary of Huxley. Authority and science were at one time in conflict over matters entirely within the province of the latter. The weapons were keen, and the strife bitter. We may rejoice that these antagonisms are now almost obsolete; one side has become more tolerant, the other less aggressive, and there is a disposition on both sides to respect each other's territories. The change is even reflected in the sermons delivered before the association. The quarters where we may look for suspicion and dislike are now different; they are political rather than ecclesiastical. The habit of sober and accurate analysis which scientific pursuits tend to promote is not always favorable to social and economic theories which rest mainly on an emotional if very natural basis. Some of us, for instance, may remember Huxley's merciless dissection of the theory of the social contract. There is hence to be traced, I think, a certain dumb hostility which, without venturing on open attack, looks coldly on scientific work except so far as it is directed to purposes of obvious and immediate practical utility.

There is a more open kind of criticism to which we are exposed, which we can not altogether ignore, though it again rests on a misconception of the true function of science. It is to be met with in quarters where we might fairly look for countenance and sympathy, and is expressed sometimes with great force and even eloquence. The burden is one of disappointment and disillusion; we even hear of the "bankruptcy of science." It seems to be suggested that science has at one time or other held out promises which it has been impotent to fulfil, that vague but alluring hopes which it has inspired have proved delusive. It may be admitted that extravagant and impossible claims have sometimes been made on behalf of science, but never, I think, by the real leaders, who have always been most modest in their claims and guarded in their forecasts. It is true again that in the enthusiasm

which attended the first sensational developments of modern industry hopes were conceived of a new era, where prosperity would ever increase, poverty would be at least mitigated and refined, national antipathies would be reconciled. When these dreams did not swiftly come true there was the inevitable reaction, the idols were cast down, and science in general has rather unreasonably come in for its share of depreciation. The attitude which I have been trying to describe is put very forcibly in a quotation from President Wilson which I saw not long ago, though its date is not very recent:

> Science has bred in us a spirit of experiment and a contempt for the past. It made us credulous of quick improvement, hopeful of discovering panaceas, confident of success in every new thing. . . . I should fear nothing better than utter destruction from a revolution conceived and led in the scientific spirit. Science has not changed the laws of social growth or betterment. Science has not changed the nature of society, has not made history a whit easier to understand, human nature a whit easier to reform. It has won for us a great liberty in the physical world, a liberty from superstitious fear and from disease, a freedom to use nature as a familiar servant; but it has not freed us from ourselves.

The tone is one of bitter disillusion, but we may ask why should science, as we understand it, be held responsible for the failure of hopes which it can never have authorized? Its province as I have tried to define it is vast, but has its limits. It can have no pretensions to improve human nature; it may alter the environment, multiply the resources, widen the intellectual prospect, but it can not fairly be asked to bear the responsibility for the use which is made of these gifts. That must be determined by other and, let us admit it, higher considerations. Medical science, for instance, has given us longer and healthier lives; it is not responsible for the use which we make of those lives. It may give increased vitality to the wicked as well as the just, but we would not, on that account, close our hospitals or condemn our doctors.

In spite of the criticisms I have referred to, we may still hold up our heads, let us hope without arrogance, but with the confidence that our efforts have their place, not a mean one, in human activities, and that they tend, if often in unimagined ways, to increase the intellectual and the material and even the esthetic possessions of the world. And in that assurance, we may rejoice that science has never been so widely and so enthusiastically cultivated as at the present time, with so complete sincerity; or (we may claim) with more brilliant success, or even with less of international jealousy.

Passing from these reflections which are, I hope, not altogether inopportune, it is expected that the president for the time being should deal with some subject in which he has himself been interested. For a mathematician this obligation is a specially difficult one, if he is not to overstrain the patience of his audience. I propose to speak briefly, and mainly from the mathematical and physical standpoint, about some branches of geophysics, and in particular those relating to the constitution of the earth. It is a subject which in the past has often engaged the attention of the association; I need only recall the names of Kelvin and George Darwin, and the controversies with which they are associated. Historically, it is of special interest to the mathematician and the physicist, for it was in his researches on the figure of the earth that Laplace initiated the theory of its potential, with its characteristic equation, and so prepared the way for Poisson, Green, Cauchy, and a host of followers, who developed the theory of electricity and ultimately that of light. To go further back, it was in this connection that Newton found an important verification of his law of gravity. Quite recently, the whole subject has been reviewed in a valuable treatise by Dr. Jeffreys, who arrives at conclusions which are at all events definite, and maintained with great ability.

I do not propose to deal with the fascinating speculations as to the past history of the earth and its reputed child, the moon, which will be more or less familiar. I must confine myself to a rapid survey of the information as to its present constitution which can be gathered from observations made in our own time, and capable of repetition at will. This, though less exciting, is at all events a region in which imagination is more subject to control.

The accurate investigation of the figure of the earth is intimately connected with the variation of gravity over its surface. In view of the local irregularities, some convention was necessary as to what is meant by the shape of the earth as a whole. The usual definition is that it is a level surface as regards the resultant of true gravity and centrifugal force: often that particular level surface of which the sea forms a part. I need not dwell on the immense amount of theoretical and practical labor which has been devoted in various countries to the determination of the geometrical surface which most nearly satisfies this requirement. Of more recent interest are the irregularities in the intensity of gravity, which have been found to exist over wide areas, by the highly trained Survey of India, by the Coast and Geodetic Survey of the United States, and by various observers on the continent of Europe. Briefly, the general result is this, that in mountainous regions the observed value of gravity is abnormally low, whilst on oceanic islands, and so far as can be ascertained on the sea, it is abnormally large, when all allowance has been made

for altitude and the normal variation with latitude. The fact that this has been found to be the case in so many different places shows that we have here to deal with no casual phenomenon. The accepted explanation, originated by Archdeacon Pratt, of Calcutta, in 1859, and since developed especially by Hayford and Bowie, of the U. S. Coast and Geodetic Survey, is that if we imagine a level surface to be drawn at a depth of about 100 kilometers, the stratum of matter above this, though varying in density from point to point, is approximately uniform, in the sense that equal areas of the surface in question bear equal weights. The altitude of the mountains is held to be compensated by the inferior density of the underlying matter, whilst the oceanic hollows are made up for by increased density beneath. Leaving aside the technical evidence on which this hypothesis is based, there are one or two points to be noticed. In the first place it suggests, as is highly plausible on other grounds, that the matter in the interior of the earth, below the stratum referred to, is in a state of purely hydrostatic stress, *i.e.*, of pressure uniform in all directions. So far as this stratum is concerned, it might be floating on an internal globe of liquid, although no assertion is really made, or is necessary, to this effect. But in the stratum itself, shearing forces must be present, and it is necessary to consider whether the actual material is strong enough to withstand the weight of continents and mountains, and the lack of lateral support due to the oceanic depressions. The researches of Professor Love and others show that this question can fairly be answered in the affirmative.

The accurate determination of the acceleration of gravity at any place is, of course, a matter of great delicacy. Not to mention other points, in the pendulum method the yielding of the support due to the reaction of the pendulum as it swings to and fro affects the time of oscillation. It may be recalled that so far back as 1818 Kater, in his absolute determination of the length of the seconds pendulum in London, was on his guard against this effect, and devised a test to make sure that it was in his case negligible. In a portable apparatus, such as is used for comparative determinations, it is difficult to give sufficient rigidity to the support, and a correction has, in some way, to be applied. Recently, Dr. Victor Meinesz, of the Dutch Survey, who has carried out an extensive gravity survey in Holland, has sought to minimize this effect by the use of pairs of pendulums swinging in opposite phases, and so reacting on the support in opposite senses. This has opened out a prospect of accurate gravity determinations at sea. The use of a pendulum method on a surface vessel is hardly possible, but a submarine when sufficiently immersed offers comparative tranquility, and it is hoped that the small residual horizontal motions may be capable of elimination, and the diminished vertical oscillation allowed for. The methods previously employed at sea which could claim any accuracy are those of Hecker. In one method, the pressure of the atmosphere is found in absolute measure from the boiling point of water and compared with the gravitational measure afforded by the barometer. In a more recent method, also devised by Hecker, and followed with some modifications by Duffield, the idea is to carry about a standard atmosphere, *i.e.*, a mass of air at constant volume and prescribed temperature, whose pressure is measured gravitationally by the barometer. Both methods are highly ingenious, but can not compete as regards accuracy with the pendulum method if this should be found practicable.

It is a matter of regret that the observational side of geophysics has, of late, been so little cultivated in this country. In India, with its wide opportunities, geodetic and gravitational work has long been carried on with high efficiency and has furnished essential material for the generalizations I have referred to. But in the home country, although we have an admirable topographical survey—whose headquarters by the way are here in Southampton—nothing so far as I know has been done towards a gravity survey since the time of Kater, more than a century ago. Proposals for the establishment of a formal geodetic institute, such as existed in some other countries before the war, which should embrace this as well as other subjects, have been urged, but have had to be abandoned owing to the exigencies of the time. It is therefore some satisfaction to record that a modest beginning has been made at Cambridge by the institution of a readership in geodesy, and that when the requisite pendulum outfit is complete, it is hoped that a gravity survey of these islands may be initiated. The physical features are hardly so rugged that sensational results such as were found in India are to be expected, but it is desirable that the work, which will involve comparatively little labor and expense after the initial steps, should be carried out. The example of Holland shows that in a country which has no outstanding features at all a survey may reveal peculiarities which are at all events of considerable interest. I may add that it is contemplated that the Cambridge apparatus should also be designed to eliminate the disturbing element I have mentioned, and that it should be available for determinations at sea. It is perhaps not too much to hope that with the cooperation of the navy, the

gravity chart of the world, which is so far almost a blank as regards the ocean, may in this way be gradually filled in.

The distribution of the intensity of gravity over the surface of the earth gives by itself no positive information as to the distribution of density throughout the interior, though the contrary view has sometimes been held. For example, a spherical globe with a uniform intensity of gravitation over its surface would not necessarily be homogeneous, or even composed of spherical strata each of uniform density, however plausible this might be on other grounds. Consequently, there is room for hypothesis. There are certain tests which any hypothesis has to satisfy. It must account for the observed distribution of gravity, and having regard to the phenomena of precession, it must give the proper relation between the earth's moments of inertia about a polar and an equatorial axis. It may be added that it should be fairly consistent with the ascertained velocities of seismic waves at different depths, and the degree of elasticity which it is allowable to assign to the material. The somewhat artificial laws of density adopted by Laplace and Roche, respectively, mainly on grounds of mathematical convenience, have lost much of their credit. A more natural law, suggested indeed by Thomson and Tait in 1867 in their book on "Natural Philosophy," has since been proposed in a more definite form by Wiechert. On this view, the earth is made up of a central core of about four fifths the external radius, of high density, about that of iron, surrounded by an envelope of about the density of the surface rocks. This is, of course, only to be taken as a rough picture, but it satisfies the requirements I have mentioned, and is apparently not incompatible with the seismic data.

In all speculations on the present subject, considerations as to the thermal history of the earth and the present distribution of temperature in the interior play an essential part. The apparent inconsistency between the requirements of physics and geology was long a matter of controversy, and has given rise to keen debate at these meetings. Lord Kelvin's historic attempts to limit the age of the earth by consideration of the observed temperature gradient as we go downwards from the surface lost their basis when it was discovered that the rate of generation of heat in the processes of radioactive change was amply sufficient to account for the present gradient, and would even be far more than sufficient unless the amount of radioactive material concerned were strictly limited. Assuming an average distribution of such material similar to what is found near the surface, a stratum of some 16 kilometers in thickness would provide all that is wanted. Radioactive speculation has gone further. A comparison of the amounts of uranium and of the end-products associated with it has led to estimates of the time that has elapsed since the final consolidation of the earth's crust. The conclusion is that it must lie definitely between 10^9 and 10^{10} years. The figure is necessarily vague owing to the rough value of some of the data, but even the lower of these limits is one which geologists and biologists are, I believe, willing to accept, as giving ample scope for the drama of evolution. We may say that physics has at length amply atoned for the grudging allowance of time which it was once disposed to accord for the processes of geological and biological change. The radioactive arguments on which these estimates are based are apparently irrefutable; but from the physical point of view, there are reasons why one would welcome an extension even of the upper limit of 10^{10} years, if this could possibly be stretched. For if this barrier be immovable, we are led to conclusions as to the present internal temperature of the earth which are not quite easy to reconcile with the evidence as to rigidity to be referred to in a moment. In the space of time I have mentioned, enormous as it is, the great mass of the earth could hardly have cooled very much from the temperature when it was in a state of fusion. The central portion, whatever its nature, and however high its thermal conductivity, is enclosed by a thick envelope of feebly conducting material, just as a steam boiler, for instance, may be jacketed with a layer of asbestos. To take a calculable hypothesis, we may assume with Wiechert that we have a central core of three fourths the earth's radius, with an outer shell of rock. We may give the core any degree of conductivity we like, for mathematical simplicity we may even regard it as infinite. Then, if the outer layer consists of material having some such conductivity as the surface rocks, the internal temperature would take to fall to one half its original value a period of at least ten times the limit I have named. It is obvious that the details of the assumption may be greatly varied without affecting the general conclusion of a very high internal temperature.

The question as to the degree of rigidity of the earth has so often been dealt with that a brief recapitulation will suffice. It was about the year 1862 that Kelvin first pointed out that if the earth as a whole were only as rigid as a globe of glass or even steel, it would yield so much to the deforming action of the solar and lunar tidal forces as seriously to affect the amplitudes of the oceanic tides, which are a differential effect. Unfortunately, the tides are so much complicated by the irregular distribution of land and sea that a comparison of the theoretical amounts which they would have on the hypothesis of

absolute rigidity with the actual values is hopeless. The fortnightly tidal component, due to the changing declination of the moon, is probably an exception, but the difficulty here is to extract this relatively minute component from the observations, and the material is consequently imperfect. The problem was attacked in a different way by G. and H. Darwin in 1881. The horizontal component of the lunar and solar disturbing forces must deflect the apparent vertical, and it was sought to measure this effect by a pendulum. The quantities to be determined are so excessively minute, and the other disturbing forces so difficult to eliminate, that the method was only carried out successfully by Hecker in 1907, and subsequently by Orloff in Russia. The results on the whole were to the effect that the observed deflections were about three fifths of what they ought to be if the earth were perfectly unyielding, and were so far in accordance with estimates previously made by Darwin and others, from the somewhat imperfect statistics of the fortnightly tide. There was, however, a discrepancy between the results deduced from the deflections in the meridian and at right angles to it, which gave rise to much perplexity. The question was finally set at rest by Michelson in 1916. He conceived the idea of measuring the tides produced in two canals (really two pipes half filled with water) of about 500 feet long, extending one N. and S., the other E. and W. These tides are, of course, of a microscopic character, their range is of the order of one hundredth of a millimeter, and they could only be detected by the refined optical methods which Michelson himself has devised. The observations, when plotted on a magnified scale, exhibit all the usual features of a tide-gauge record, the alternation of spring and neap tides, the diurnal and semi-diurnal lunar tides, and so on. The theoretical tides in the canals can, of course, be calculated with great ease, and the comparison led to the result that the ratio which the observed tides bore to the theoretical was about .69, being practically the same in both cases. The whole enterprise was as remarkable for the courage of its inception as for the skill with which it was carried out, and was worthy of the genius which has accomplished so many marvels of celestial and terrestrial measurement. The perplexing discrepancy in the results obtained by Hecker at Potsdam is no doubt to be explained by the attraction of the tidal waters in the not very remote North Sea, and by the deformation due to the alternating load which they impose on the bottom. In Chicago, near the center of the American continent, these influences were absent.

The question may be asked, What is the precise degree of rigidity which is indicated by these observations, or by others which have been referred to? Various answers have been given, based on observations of the tides, of the lunar deflection of the vertical, and of the period of the earth's Eulerian mutation, on which I have not touched. The estimates have varied greatly, but they are all high, some of them extremely high. That they should differ among themselves is not surprising. The material is certainly not uniform, either in its elastic properties or the conditions to which it is subject, so that we can only speak of the rigidity of the earth as a whole in some conventional sense. Larmor and Love have shown that all the information that can be gathered, whether from the tides or from the Eulerian mutation, can be condensed into two numerical constants. This leaves a large degree of indeterminateness as to the actual distribution of elasticity within the earth. It is at all events certain that in regard to tidal forces the great bulk of the material must be highly rigid.

In leaving this topic, it may be recalled that it was in this same connection that Kelvin was led to initiate the method of harmonic analysis as applied to the tides, as well as to accomplish much brilliant mathematical work, whose importance is by no means limited to the present subject. The whole theory of the tides and cognate cosmical questions afterwards became the special province of George Darwin, but after his death, work on the tides was almost at a standstill, until it was resumed by Professor Proudman and his associate, Dr. Doodson, in the recently established Tidal Institute at Liverpool. They have already arrived at results of great theoretic as well as practical interest, some of which I understand are to be brought before the association at this meeting.

Within the last twenty years or so, light has come on the elastic properties of the earth from a new and unexpected quarter, *viz.*, from a study of the propagation of earthquake shocks. It is pleasant to recall that this has been largely due to efforts especially fostered, so far as its means allowed, by this association. To John Milne, more than to any one else, is due the inception of a system of widely scattered seismological stations. The instruments which he devised have been improved upon by others, notably by Galitzin, but it is mainly to his initiative that we are indebted for such insight as has been gained into the elastic character of the materials of the earth, down, at least, to a depth of half the radius. It may be remarked that the theory of elastic waves, which is here involved, was initiated and developed in quite a different connection, in the persistent but vain attempts to construct a mechanical representation of

the luminiferous ether which exercised the mathematical physicists of a generation or two ago. It has here at length found its natural application. One of the first problems of seismologists has been to construct, from observation, tables which should give the time an elastic wave of either of the two cardinal types—*viz.*, of longitudinal and transverse vibration—takes to travel from any one point of the earth's surface to any other. It has been shown by Herglotz and Bateman that if these data were accurately known it should be possible, though naturally by a very indirect process, to deduce the velocities of propagation of the two types throughout the interior. Such tables have been propounded, and are in current use for the purpose of fixing the locality of a distant earthquake when this is not otherwise known. They are however admittedly imperfect, owing to the difficulty of allowing for the depth of the focus, which is not always near the surface, and is sometimes deep-seated. This uncertainty affects, of course, the observational material on which the tables are based. Some partial corrections have been made by Professor Turner, who almost alone in this country, amidst many distractions, keeps the study of seismology alive, but the construction of accurate tables remains the most urgent problem in the subject. Taking however the material, such as it is, the late Professor Knott, a few years ago, undertook the laborious task of carrying out the inverse process of deducing the internal velocities of the two types of waves referred to. Although it is possible that his conclusions may have to be revised in the light of improved data, and, it may be, improved methods of calculation, they appear to afford a fairly accurate estimate of the wave velocities from the surface down to a depth of more than half the earth's radius. Near the surface the two types have velocities of about 7.2 and 4 km per second, respectively. These velocities increase almost uniformly as we descend, until a depth of one third the radius is reached, after which, so far as they can be traced, they have constant values of 12.7 and 6.8 km per second, which, by the way, considerably exceed the corresponding velocities in iron under ordinary conditions. The innermost core of the earth, *i.e.*, a region extending from the center to about one fourth of the radius, remains somewhat mysterious. It can certainly propagate condensational waves, but the secondary waves are hard to identify beyond a distance of 120° of arc from the source of disturbance. Knott himself inferred that the material of the central core is unable to withstand shearing stress, just as if it were fluid, but this must at present remain, I think, uncertain.

It should be remarked that the wave-velocities by themselves do not furnish any information as to the elasticities or the density of the material, since they involve only the ratios of these quantities. The relation between the two velocities is, however, significant, and it is satisfactory to note that it has much the same value as in ordinary metals or glass.

It is to be regretted that at present so little is being done in the way of interpretation of seismic records. Material support in the way of more and better equipped stations is certainly needed, but what is wanted above all is the coordination of such evidence as exists, the construction of more accurate tables, and the comparative study of graphical records. These latter present many features which are at present hard to interpret, and a systematic comparison of records of the same earthquake obtained at different stations, especially if these are equipped with standardized instruments, should lead to results of great theoretical interest. The task will be a difficult one, but until it is accomplished we are in the position of a scholar who can guess a few words in an ancient text, possibly the most significant, but to whom the rest is obscure.

Even on this rapid review of the subject it should be clear that there is an apparent inconsistency between the results of two lines of argument. On the one hand, the thermal evidence points to the existence of a high temperature at a depth which is no great fraction of the earth's radius, so high indeed as to suggest a plastic condition which would readily yield to shearing stress. On the other hand, the tidal arguments, as well as the free propagation of waves of transversal vibration at great depths, indicate with certainty something like perfect elasticity in the mathematical sense. The material with which we are concerned is under conditions far removed from any of which we have experience; the pressures, for instance, are enormous; and it is possibly in this direction that the solution of the difficulty is to be sought. We have some experience of substances which are plastic under long-continued stress, but which behave as rigid bodies as regards vibrations of short period, although this combination of properties is, I think, only met with at moderate temperatures. It is conceivable that we have here a true analogy, and that the material in question, under its special conditions, though plastic under steady application of force, as for instance centrifugal force, may be practically rigid as regards oscillatory forces, even when their period is so long as a day or a fortnight. But beyond that we can hardly, with confidence, go at present.

I have chosen the preceding subject for this address, partly because it has not recently been reviewed at these meetings, and also for the opportunity it has given of urging one or two special points. It

is evidently far from exhausted—the loose ends have indeed been manifest—but this should render it more interesting. It furnishes also an instance, not so familiar as some, of the way in which speculations which appear remote from common interests may ultimately have an important influence on the progress of science. It is true that the secular investigations into the form of the earth's surface have an importance in relation to geodesy, but certainly no one at the time of Laplace's work on this matter would have guessed that he was unwittingly laying the foundation of the whole mathematical theory of electricity. The history of science is indeed full of examples where one branch of science has profited by another in unexpected ways. I would take leave just to mention two, which happen to have specially interested me. It is, I think, not generally understood what an important part the theory of elasticity played in Rayleigh's classical determinations of the relative weights of the gases, where it supplied an important and indeed essential correction. Again, the mathematical theory of hydrodynamics, in spite of some notable successes, has often been classed as a piece of pure mathematics dealing with an ideal and impossible fluid, elegant indeed, but helpless to account for such an every-day matter as the turbulent flow of water through a pipe. Recently, however, at the hands of Prandtl, it has yielded the best available scheme of the forces on an aeroplane, and is even being appealed to to explain the still perplexing problem of the screw-propeller.

To promote this interaction between different branches of science is one of the most important functions of our association, and differentiates it from the various sectional congresses which have from time to time been arranged. We may hope that this meeting, equally with former ones, may contribute to this desirable end.

Let me close with a local reference. The last fifty years have seen the institution of local universities and university colleges in many parts of this country and of the Empire at large. Through these agencies the delights of literature, the discipline of science, have been brought within the reach of thousands whose horizons have been enlarged and their whole outlook on life transformed. They have become centers, too, from which valuable original work in scholarship, history and science has radiated. The University College of Southampton is now contemplating an increased activity and a fuller development. In this ambition it has, I am sure, the best wishes of us all.

HORACE LAMB

SCIENCE AND SOCIAL ETHICS[1]

PRIMITIVE man, with his rudimentary knowledge of good and evil, could not attain a level of existence much above that of the brutes, in spite of the superiority of his brain. Even to-day, men live almost as wild animals in the tropical forests of South America. The remains of Paleolithic man in Europe show us that he had a brain as large as ours, and his art proves his capacity for understanding; yet he lived in what we consider a barbaric state. Gradually, by slow and painful steps, he acquired knowledge and with its aid developed skill and undertook what we call, with boastful exaggeration, the conquest of nature. In reality, he learned to play a game with nature, increasingly complex and productive of results as he learned more and more of the rules. This game, as we now find it, is what we call civilization, and it needs little argument to prove that for its maintenance we require all the knowledge we can obtain, organized into what we call science. We can not even remain where we are; we are compelled by the logic of events to go forward or backward, and progress depends on knowledge. Good intentions are of little avail without it, and the ignorant are like poor players who, doing the best they can, ruin the music of an orchestra. Thus it is impossible to be good without being wise, if we understand the word good in a pragmatic sense, as meaning good for something. Yet we must agree that science alone can not adequately minister to human needs. If a human being is nothing more than a temporary arrangement of atoms of carbon, hydrogen, oxygen, nitrogen and some other elements, our whole conception of human values seems to have little basis in reality. Or rather, is what reality it possesses unstable, evanescent, insignificant in relation to the universe? Is human life a tragedy because a comedy, a thing so ridiculous with its serious poses and heroic gestures that the gods, if there be such, must be convulsed with laughter? Well, we do not believe that for a moment; we could not believe it and be sane. Huxley was perhaps the most typical exponent of modern science, yet his great friend Michael Foster had this to say of him:

> Great as he felt science to be, he was well aware that science could never lay its hand, could never touch even with the tip of its finger, that dream with which our little life is rounded; and that unknown dream was a power as dominant over him as was the might of known science; he carried about with him every day that which he did not know as his guide of life no less to be minded than that which he did know.

[1] Read at the symposium held by the Southwestern Division of the American Association for the Advancement of Science, Boulder, June 8, 1925.

Recently, having occasion to write an article in commemoration of the hundredth anniversary of Huxley's birth, I tried to imagine what his counsel would be, were he among us. I fancied that it might be somewhat as follows:

> You can not have successful democracy without moral sense, and that must show itself equally in tenderness of heart and honesty of purpose. It is not enough to mean well; you must do well, cooperating with the universe in which you live. The honest man faces the facts of existence and governs his conduct accordingly; he throws aside all sham and pretense, as soon as it is ascertained to be such. These are not mere pleasing generalities, but stern precepts in a land where ignorance is often enthroned, and masses of people pretend to believe that which in their hearts they know to be false. Power without wisdom, action without knowledge, must lead to catastrophe, no matter how excellent the political system, how worthy the traditions of the past.[2]

There was a splendid integrity about some of the prophets of old, who offered eternal wisdom in the setting of the knowledge of their day. Yet the parable of the new wine in old bottles shows that our modern dilemma is of very respectable antiquity. It is not difficult to perceive what Jesus Christ would have to say about it, were he once more a man among men. Just as we have made over our lives to suit modern invention and discovery, so must we make over our philosophy to suit modern knowledge. But in essence both the lives and the philosophy remain the same, or at least retain eternal elements. Are we to perish like some butterfly which, having attained the winged state, should insist upon trying to eat cabbage leaves, instead of sucking the nectar of flowers? The matter is of enormous importance, and we must concede this virtue to the enemies of science, that they perceive it to be such. Unquestionably, the progress of the modern world, in its varied aspects, severely taxes the stability and even the sanity of the modern mind. Since we can not go back to barbarism, and all agree on that, it only remains to make readjustments which shall create harmony rather than discord, wholesomeness rather than a chaos of disconnected and irreconcilable fragments. What does this actually involve? It seems to me that it involves on the one hand the possession of what William James called over beliefs, transcendental conceptions of value and virtue which find their main justification outside the field of science; and, on the other, a frank and full acceptance of the testimony of the human senses, not as rigid orthodoxy, but as something dynamic, ever converting reality into truth. The modern man, possessed with these ideas, is bound to reject the mass of ancient miracles, some as apparently pure inventions, others as misinterpretations of facts actually observed. He may still often use metaphor, because our language is full of it, and perhaps the more freely because he knows what he is trying to express. He will not lose the sense of mystery or the feeling of awe, as he contemplates the world about him. Rather, these feelings will be deepened and broadened, as he perceives that truth is ten thousand times more wonderful than any fiction.

What can he say to those who fear that the loss of faith in the images of the past will imperil the essential verities? He can not, he must not, treat the matter lightly, as a thing of no account. The danger is real, and the problem has to be met. But Christ long ago pointed out the futility of trying to meet it in a half-hearted way. The new wine would burst the old bottles, and everything would be lost. This we can not endure, any of us, and those who would insist on confining the growing, living science and religion of the day within the boundaries of ancient tradition are themselves the wasters of that which they hold most precious.

T. D. A. COCKERELL

UNIVERSITY OF COLORADO

[2] *Nature*, May 9, 1925, p. 750.

SCIENTIFIC EVENTS

RUSSIAN SCIENTIFIC EXPEDITIONS

ACCORDING to the New York Bureau of the Russian Telegraph Agency an expedition is being sent into the provinces of Saratov and Ulyanovsk (formerly Simbirsk) to study the vicissitudes of culture during the prehistoric period on the Volga river, the main waterway of the East European plain.

An expedition is leaving for Daghestan and the surrounding territories to study the languages, monuments, architecture, art and antiquities of Daghestan.

A four-months' excursion is being organized to Krasnokokshaisk, Penza, Kazan and Sarapul to study the language and culture of the Finnish races in those districts, particularly of the Mari, Votiaks and Mordvans.

A series of scientific expeditions is being organized to Central Asia. The first expedition will leave for the lake of Issik-Kul to investigate the possibilities of establishing large fisheries which may prove of great economic importance. Another expedition will be sent to the mountainous region of Turkmenistan to gather materials on the flora and fauna of that region. An expedition is being organized to Kazakistan (Kirghiz Republic) to gather valuable fossils of animals and plants contained in the slate deposits of the marine period. Other expeditions were sent to the Pamire and Tadjighistan.

The largest expedition has been sent to Northern Ferghana to study the rich natural resources of the region.

Another expedition is leaving for Yakutia for a period of five years. The expedition will study the life and customs of the Yakuts, the physical types of the population, the spread and causes of such diseases as trachoma, leprosy and psychiatrical phenomena observed in Yakutia, the cause of the degeneration of the Yakut women, and so on.

THE A. C. S. NEWS SERVICE

IN response to a request from the editor of SCIENCE I am glad to give the following details regarding the News Service of the American Chemical Society.

The service was founded in 1917 with Dr. Allen Rogers, of Pratt Institute, contributing part time to its management. The work was later transferred to the office of the editor of *Industrial and Engineering Chemistry,* and with the increase in the work a managing editor was later employed. No record of returns was kept in the early history of the service, but beginning with 1918 clippings were collected through the regular channels and their total tabulated with the full realization that clipping bureaus are probably not more than 30 per cent. efficient, by which we mean that they probably collect not more than 30 per cent. of the articles printed on a given piece of news.

The following figures as to cost and inches of publicity may be of interest:

	Cost	Inches Publicity
1917	$ 500	No record
1918	1,850	5,000
1919	2,069	8,000
1920	8,078	21,000
1921	12,792	70,000
1922	10,306	79,101
1923	8,154	115,000
1924	6,580	205,000

Present indications are that 1925 will see a further satisfactory increase in our return. We are proud of the record, not merely because it indicates extensive space having been devoted to chemistry, but because of the high character of the mediums which have seen fit to use our releases.

While the editor of *Industrial and Engineering Chemistry* is the director of the News Service, the actual rewriting and placing of the stories is done by an experienced newspaper man who serves as managing editor. Special stories are frequently written, not only for given periodicals but in accordance with geographic interest in some new topic.

There is no monetary return to the society for this work, but the chemists believe that the expenditure is amply justified, for many instances of returns in a broad sense can be noted and it is felt that the creation of a large body of public opinion sympathetic to the work of chemistry is certain to redound to the advancement of the science in America.

The News Service was begun at a time when the press generally was inclined to print sensational stories, most of which were grossly inaccurate or mere figments of the imagination. There has been a decided decrease in this tendency and at present we are frequently solicited for information on topics before newspapers even write their own stories. Thanks to the News Service and to other educational efforts, it is not uncommon for special reporters to be assigned to the semi-annual meetings of the American Chemical Society. Other scientific organizations have from time to time engaged upon publicity campaigns and it is felt that the results of the American Chemical Society's efforts compare well with those obtained by similar organizations.

H. E. HOWE,
Editor

PLANS FOR LUTHER BURBANK'S EXPERIMENTAL FARM

TENTATIVE plans have been made by Stanford University to take over and perpetuate the work of Luther Burbank, according to announcement made by William Gibbs McAdoo, member of the advisory board interested in the project.

The plans contemplate the transfer of Burbank's experimental farm at Sebastopol to the control of Stanford University, which will set about raising an endowment fund sufficient to insure the carrying on of Burbank's work when the horticulturist ceases his labor of creating new plants and flowers and improving on present species.

Burbank, for the past two years, has gradually been getting his affairs in shape so that his experimental farm might be taken over by some qualified institution. The proposal met with a ready response from Stanford University, owing to the warm personal friendship existing between Dr. David Starr Jordan and Luther Burbank. The announcement indicated that the university authorities had definitely taken up the project and would seek to raise the necessary endowment funds.

In his statement, Mr. McAdoo said:

For a period of fifty years Luther Burbank has been doing marvelous things in the field of horticulture—things that have conferred immeasurable benefits upon the human race.

Mr. Burbank has done most of his epochal work on a thirteen-acre development farm at Sebastopol, Sonoma

County, Calif., about seven miles from his home at Santa Rosa. Here is the original giant "Royal" hybrid walnut tree which for fifteen years has paid in nuts and grafts 6 per cent. annual interest on $10,000. There are 13,209 large and small "Royal" hybrid walnut trees. There are 14,846 new seedling hybrid chestnut trees; 188 hybrid and seedling mountain ash, 802 new Patagonia hybrid and seedling cherry trees, 1,499 plum and prune trees, all new hybrids, bearing some 2,000 new varieties. All told, there are some 200 different departments of horticultural perfection, numbering many thousands of choicest plants, trees and perfected vegetables and berries.

Stanford University desires to acquire and conduct this development farm as the Luther Burbank horticultural unit of Stanford University. The conditions under which Stanford University was established make it necessary that all units have their individual endowment.

Luther Burbank, with a generous purpose to perpetuate the useful work he has already done for humanity, has made it possible for Stanford University to obtain this development farm at Sebastopol with its wealth of horticultural materials. As Mr. Burbank's contribution to the endowment fund, he is willing to transfer the property at a small part of its cost and real value to him.

ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY

THE Nineteenth Annual Convention of the Illuminating Engineering Society is to be held in Detroit, September 15 to 18, 1925, with headquarters at the Hotel Statler. This meeting will mark the inauguration of the new Michigan Section which will be observed by appropriate exercises.

In addition to the president's reception and dance which is to be held on Tuesday evening, the banquet will be held on Thursday evening and the golf tournament on Wednesday morning. The Entertainment Committee has provided a number of special features of interest to the ladies and it is hoped that there will be many in attendance to enjoy the program provided. Prizes are to be awarded for games and sports events.

Monday, September 14, the day preceding the convention, has been set aside for a number of special activities, meetings, etc., as noted below:

(a) Special Committee meetings (details will be supplied by Committee Chairmen).

(b) A meeting of all persons interested in the development of the Society and its sections, to be conducted by the President-elect, Mr. M. Luckiesh.

(c) A meeting under the auspices of the Committee on Constitutional Revision, to discuss some rather radical changes in the Constitution which have been proposed.

(d) A meeting especially for central-station lighting representatives and others interested in the development of lighting service, at which there will be held a round-table conference on the operation of central-station lighting bureaus. This will be followed by a dinner and inspection trip to representative installations of show-window and industrial lighting.

TUESDAY, SEPTEMBER 15TH

9:00 A. M.—Registration.

10:00 A. M.—Address of welcome—Alex Dow.
Response to address of welcome.
President's address.
Report of general secretary.
Committee reports.

2:30 P. M.—Report of committee on motor vehicle lighting.
Paper—Improved automobile headlighting—A. W. Devine.
Paper—Depressible beam headlighting—R. N. Falge.
Paper—Late developments in traffic control—C. A. B. Halvorson, Jr.

8:30 P. M.—President's reception and dance.

WEDNESDAY, SEPTEMBER 16TH

8:30 A. M.—Golf tournament.

2:30 P. M.—Report of committee on natural lighting.
Paper—Practical daylight calculations for vertical windows—W. S. Brown.
Paper—Sawtooth design, its effect on natural illumination—W. C. Randall.
Paper—Prediction of daylight from sloping windows—H. H. Higbie and A. Levin.
Paper—Relative value of daylight, tungsten filament and mercury arc light and mixtures, as measured by visual acuity—Frank E. Carlson.
Paper—The effect of mixing artificial light with daylight on important functions of the eye—C. E. Ferree and G. Rand.

THURSDAY, SEPTEMBER 17TH

9:30 A. M.—Symposium on residential street lighting.
Paper—The fading of colored materials by daylight and artificial light—M. Luckiesh and A. H. Taylor.
Paper—Lighting for production—P. W. Cobb.

2:30 P. M.—Paper—Lighting of show windows during daylight hours—(demonstration) Messrs. E. D. Tillson, O. R. Hogue and Charles Howard.
Paper—Automobile body plant lighting—J. M. Ketch, H. J. Thompson and E. F. Labadie.
Paper—The illumination of general electric factories, offices and warehouses—By works illumination advisory com-

mittee—W. D'A. Ryan, *chairman*, Ward Harrison, G. H. Stickney, C. A. B. Halvorson, Jr., and H. E. Mahan.

7:30 P. M.—Banquet, Hotel Statler.

FRIDAY, SEPTEMBER 18TH

9:30 A. M.—Paper—Recent developments in neon lamps—D. McFarlan Moore and L. C. Porter.

Paper—A practical form of photoelectric photometer—Clayton H. Sharp and Carl Kinsley.

Paper—Isocandles—Frank Benford.

Paper—New methods of showing photometric data—Samuel G. Hibben.

Paper—Reflection properties of chromium—R. J. Piersol.

SCIENTIFIC NOTES AND NEWS

THE next meeting of the British Association for the Advancement of Science will take place next summer at Oxford under the presidency of the Prince of Wales. At the recent Southampton meeting it was voted that invitations should be issued next year irrespective of nationality.

PROFESSOR KUSTNER, director of the observatory at Bonn, has been elected a corresponding member of the Real Accademia dei Lincei of Rome.

DR. T. MADSEN, of the Copenhagen State Serum Institute, has been elected honorary member of the Belgian Académie de Médecine.

THE French Academy has awarded the Bordin prize to the well-known psychiatrist Dr. Maurice de Fleury, member of the Académie de Médecine.

THE Ebert award of the American Pharmaceutical Association has been given to Dr. H. T. Youngker, of the Massachusetts College of Pharmacy, Boston, for a paper on the "Anatomy and botanical description of mire," presented at the last meeting.

DR. LEOPOLD S. VACCARO, an instructor in the University of Pennsylvania School of Medicine, who is in Rome in the interest of the Sesqui-Centennial Exposition, has received the honorary degree of doctor of medicine from the University of Rome.

THE American Civil Liberties Union has made plans to continue the legal fight against the Tennessee anti-evolution law. An advisory committee has been named, which consists of nineteen members, as follows: Professor Edwin G. Conklin, of Princeton University; Professor John M. Coulter, of the University of Chicago; Dr. J. McKeen Cattell, president of the Psychological Corporation; James Hardy Dillard, president of the John F. Slater Fund, Charlottesville, Va.; Dr. Charles W. Eliot, president emeritus of Harvard University; Paul Hutchinson, Chicago, editor of *The Christian Century;* David Starr Jordan, president emeritus of Leland Stanford University; Bishop Francis J. McConnell, of Pittsburgh; Rabbi Louis L. Mann, of Chicago; Dean Shailer Mathews, of the Divinity School of the University of Chicago; Professor Maynard M. Metcalf, of the Johns Hopkins University; the Rev. Charles Francis Potter, executive secretary of Antioch College; Professor Edward L. Rice, of Ohio Wesleyan University; Professor William North Rice, of Wesleyan University at Middletown, Conn.; Luther Burbank, of California; Fred Eastman, editor of *Christian Work;* the Reverend William M. Francis, archbishop of the Western Orthodox Church; Stanley High and Halford E. Luccock, of the Methodist Board of Foreign Missions, and Rabbi Nathan Krass, of Temple Emanuel.

THE Harvard Medical School will be represented by Dr. Nathaniel Allison, Dr. James H. Means, Dr. William P. Graves, Dr. Walter B. Cannon and Dr. Milton J. Rosenau, at the meeting of the Inter-State Post-Graduate Assembly of America to be held in St. Paul, Minn., from October 12 to 16.

WE learn from *Nature* that Professor J. G. McKendrick, F.R.S., the distinguished emeritus professor of physiology in the University of Glasgow, reached the age of eighty-four years on August 12, and that Sir William Tilden, F.R.S., eminent as a chemist, celebrated his eighty-third birthday on August 15.

THE retirement under a new pension law is reported of John R. Bovell, director of agriculture, Barbados, and in the service of the department since 1883.

ALFRED B. HASTINGS, associate professor of forestry in the University of Virginia and assistant state forester, has joined the United States Forestry Service as chief inspector of forestry work done cooperatively by the states and the federal service. Fred C. Peterson, formerly district forester with headquarters at Bristol, Va., has been appointed assistant state forester to succeed Mr. Hastings.

DR. DAVID STARR JORDAN, chancellor emeritus of Stanford University, and Dr. Barton Warren Evermann, director of the museum and of the Steinhart Aquarium of the California Academy of Sciences, have been invited by Alexander Hume Ford, director of the Pan-Pacific Union, to come to Honolulu to advise with him and his board regarding the policy and scope of the Pan-Pacific Scientific Research Institution recently established at Honolulu. It is Mr. Ford's earnest desire that the policy, scope and organization of the institution receive careful consideration and that its activities be laid along lines which will enable the institution to be of the greatest possible value in the

study of the problems of the Pacific, particularly those concerned with the conservation of the natural resources of the Pacific and its connecting waters. Dr. Jordan and Dr. Evermann have accepted the invitation and will sail on the *S. S. Maui* for Honolulu, September 16. They will be accompanied by Mrs. Jordan and Mrs. Evermann, and expect to spend about a month on the islands.

UNDER the direction of Professor James Henry Breasted, head of the Oriental Institute of the University of Chicago, an expedition to the ruins of the ancient fortified town of Armageddon in Palestine, the famous "battle ground of the ages," will be launched about the middle of August, when Professor Clarence Fisher, the field director just appointed, will sail from New York to begin the work. He will be followed at the end of the month by Dr. D. F. Higgins, assistant director, and E. L. De Loach, assistant geologist. Mr. John D. Rockefeller has pledged $215,000 towards the expenses of the expedition.

PROFESSOR J. J. R. MCLEOD, of the faculty of medicine of the University of Toronto, addressed the British Association for the Advancement of Science on the subject of the supply of insulin at the Southampton meeting.

SIR RONALD ROSS opened the new building of the British Mosquito Control Institute at Hayling Island on August 31.

PROFESSOR L. KOEPPE, of the University of Halle, Germany, recently gave a course of lectures at the Lakeside Hospital, Cleveland, on "Slit-lamp microscopy." Beginning on September 15, Professor Koeppe will lecture at the New York Eye and Ear Infirmary, New York.

THE Royal Photographic Society of Great Britain will celebrate the centenary of the invention of photography by Joseph Nicephore Niepce from September 14 to 24. Three of the original photographs produced by Niepce in 1825 will be displayed during the celebration. The photographs are the oldest in Britain and only recently came into the possession of the society and will be a feature of the International Exhibition of Photography to be held in connection with the celebration.

A MONUMENT to Robert Fulton, American inventor of the steamboat, will be erected in the little town of Ptombiers, Eastern France, with funds that a committee fostering the plan hopes to get through subscriptions in France and the United States. The town chosen for the monument is the place where Fulton conducted tests with a miniature steamboat on the Augronne River in 1802.

A STREET in Brussels near the university has been renamed in honor of the late Professor A. Depage.

THE death is announced of Professor W. E. Cutler, of the University of Manitoba and leader of the British Museum expedition which has been excavating dinosaurian bones in Africa.

PROFESSOR ARISTIDE STEFANI, the well-known physiologist of Padua, has recently died.

WE learn from the last issue of the *Journal of Geography* of the deaths of Henri Cordier, president of the Geographical Society of France; Adolphe Cattaui Bey, secretary-general of the Royal Egyptian Geographical Society, and of Dr. Oscar Lenz, who was formerly professor of geography in the German University at Prague.

DON LUIS CUBILLO Y MURO, director of the Geographic Institute of Spain and president of the Spanish National Committees of Geophysics and of Astronomy, died on July 10. Dr. William Bowie writes: "Much of the success which attended the meeting in October, 1924, of the International Geodetic and Geophysical Union in Madrid, Spain, was due to the untiring efforts and great affability of Dr. Cubillo. He was a man of great personal charm as well as of distinguished scientific ability and his death is a loss to international science as well as to his family and his immediate circle of friends. Under his leadership the Geographic Institute of Spain has been carrying on scientific research of great value in the field of geophysics and recent determinations of the value of gravity at various points in Spain will form a valuable contribution to scientific knowledge.

THE United States Civil Service Commission announces examination for assistant civil engineer. Receipt of applications will close October 6. The examination is to fill a vacancy in the Office of Indian Affairs for duty at San Carlos, Ariz., and vacancies occurring in positions requiring similar qualifications throughout the United States at an entrance salary of $2,400 a year. Advancement in pay may be made without change in assignment up to $3,000 a year.

THE forty-ninth annual meeting of the French Association for the Advancement of Science was opened at Grenoble on July 27, under the presidency of Emile Borel, minister of marine.

WE learn from the *Journal* of the American Medical Association that the fifth International Congress on the History of Medicine took place at the Athéneé at Geneva, from July 20 to 25, under the presidency of Dr. Charles Greene Cumston, formerly of Boston, and now instructor in medical history in the University of Geneva. Eleven nations were represented

(Belgium, Denmark, France, Great Britain, Holland, Italy, Morocco, Poland, Spain, Switzerland and the United States) and although the number of those registered was not as great as at the previous congress (influenced largely by the unfavorable rate of exchange), the percentage attending the various séances was considerably higher. Five national sections (Egypt, Greece, Portugal, Roumania and Sweden) were not represented. Each session was presided over by the representative of one of the countries participating. The next congress will be held at Leyden in July, 1927, under the presidency of Dr. J. G. de Lint.

THE sixtieth anniversary of the Society of Technical Engineers of Czechoslovakia was celebrated at Prague from June 20 to 24, 1925. The festivities, at which President Mazaryk and his ministers were present, consisted of the laying of the corner stone of the Prague Technical School, the laying of the corner stone of the building for the engineering societies and a visit to the Skoda works.

ACCORDING to the Rio de Janeiro correspondent of the *Journal* of the American Medical Association the National Academy of Medicine, the oldest of all Brazilian scientific bodies, and next to the oldest in South America, celebrated its ninety-sixth anniversary on June 30. The session assumed befitting solemnity and was presided over by the secretary of the interior. The president of the academy, Professor M. Couto, delivered an address on eugenic problems, emphasizing the rôle of health in human accomplishments. The first secretary, Dr. Belmiro Valverde, described the papers submitted during the year, and the official orator, Dr. Garfield de Almeida, recalled the merits of the members who had died during the year. The academy gold medal was granted to Dr. A. Valerio for his monograph on sciatica. The president then read the list of prizes to be awarded in the coming year.

THE first award of the Cole prize of the American Mathematical Society will be made at the end of 1927 for a notable contribution to the theory of linear algebras by a resident of the United States or Canada. The first award will be two hundred dollars. The contribution may be either an unpublished manuscript or a paper first published during 1925, 1926 or 1927. Two copies of the manuscript or printed paper should be in the hands of the secretary of the society, 501 West 116th Street, New York City, on or before October 31, 1927.

ABOUT twenty leading American colleges and universities have filed applications for their students of chemistry and chemical engineering to take the one week course of intensive training in practical technique of chemical engineering to be held in conjunction with the tenth Exposition of Chemical Industries at the Grand Central Palace, New York, during the week of September 28 to October 3. More than three hundred students are expected to enroll before the closing date. All students of recognized colleges, as well as practicing chemical engineers, who desire to brush up on fundamentals, are eligible to take the course which is without cost. Some of the leading authorities on engineering methods, materials and equipment will be among the speakers. Lectures will be held during the morning hours at the Grand Central Palace prior to the official opening of the exposition each day. Tours among the exhibits for practical demonstrations will also be conducted for the students. Examinations will be held at the close of the course as a number of colleges have designated their intentions of giving their students credit toward their degrees for work done at the Chemical Exposition. Professor W. T. Read, of the department of chemistry of Yale University, is in charge of the course.

THE *Experimental Station Record* states that a report of a committee appointed by the board of overseers at Harvard University to study the Bussey Institution recommends that the university establish a graduate department of agriculture. The committee estimates that an endowment of $12,000,000 would be required to carry out this plan in an adequate way. This sum would provide $150,000 per annum for fifteen new professorships, a like sum for the maintenance of libraries and laboratories and $24,000 per annum for fellowships. The remainder of the endowment would be available for new laboratories, greenhouses, animal houses and dormitory accommodations for the 400 students which the committee estimates would desire enrollment.

THE Ministry of Agriculture of France is establishing an Agronomic Research Institute at Clermont-Ferrand. Laboratories will be provided for plant studies from the standpoint of agricultural botany, genetics, pathology, entomology, etc. M. Crépin has been appointed director of the institute.

ON July 12 a new Geophysical Observatory at Jakutsk commenced work. Organized by the Geophysical Central Observatory, Leningrad, the new observatory represents a local branch of the Central Observatory and consists meanwhile of two sections, dealing with meteorological and the aerological work, respectively. It is expected that in due course the observatory will be equipped for actinometric, optical and magnetic observations.

UNIVERSITY AND EDUCATIONAL NOTES

THE total of funds to the credit of the $17,500,000 development program of the University of Chicago, according to an announcement by Robert P. Lamont, chairman of the committee on development, is $6,508,752. In addition, $2,134,763 has been given to the university during the campaign for other than campaign purposes, so that the total of subscriptions made to the university during the period of the campaign is $8,643,515.

WITH the gift of $1,000,000 to Washington University by Mr. Charles Rebstock, of St. Louis, will be erected a building for biology, costing $300,000; the remainder of the gift will be used for general endowment. This is one of the largest gifts the university has ever received from an individual and differs from the usual donation in that no stipulations are attached.

THE trustees of Gettysburg College have appropriated $100,000 for the construction of a new chemical laboratory.

DR. W. L. HOWARD, of the University of California, has been appointed director of the branch of the College of Agriculture at Davis in addition to his previous duties as head of the division of pomology in the university.

DR. CHARLES H. KEENE, director of health education in the department of public instruction at Harrisburg, Pa., has been appointed professor of hygiene and director of physical education at the University of Buffalo.

DR. A. K. ALDINGER, for twenty years supervisor of physical education in the schools of New York, has been appointed professor of physical education at the University of Vermont.

DR. VASIL OBRESHCOVE, associate professor of zoology at Syracuse University, has been made head of the biology department at St. Stephen's College, Annandale-on-the-Hudson.

DR. A. B. DAWSON has recently resigned his position with Loyola University School of Medicine, Chicago, to accept an appointment as associate professor of biology at New York University.

C. I. REED (Ph.D., '25, Chicago), formerly associate professor of physiology in the University of Kansas and for the past year fellow in medicine of the National Research Council, has accepted the position of associate professor of physiology in Baylor University Medical School, Dallas, Texas.

NEW appointments at the Carnegie Institute of Technology include the following: Arthur C. Jewett, formerly head of the department of mechanical engineering at the University of Maine and more recently with the Winchester Repeating Arms Co., to be director of the college of industries; William T. Crandell, of Kansas, assistant professor of commercial engineering, and Dr. Borden P. Hoover, formerly of the University of Illinois, assistant professor of mathematics.

DR. W. H. MAXWELL TELLING, who has occupied the chair of therapeutics in the University of Leeds for the past two years, has been elected professor of medicine and head of the department of medicine on the retirement from that office of Dr. T. Wardrop Griffith. Dr. R. A. Veale has been elected to the chair of therapeutics in place of Professor Telling and Dr. G. W. Watson has been elected to the chair of clinical medicine, which has been vacant since the retirement of Dr. A. G. Barrs.

DISCUSSION AND CORRESPONDENCE

BERNOUILLI'S PRINCIPLE AS CONSERVATION OF ENERGY

WHILE clearing up a doubt in the mind of a bright undergraduate the writer learned to his surprise that the old notion of "pressure energy" had reappeared in a recent edition of a popular college text on physics, with the usual application to Bernouilli's Principle. Now it is absurdly easy to show that such energy does not exist; for instance, if the pressure on a cubic centimeter of water is raised from zero to one atmosphere or 1.031×10^6 dynes per cm^2, the water is compressed by 0.000045 cc and the work done is only 46 ergs: how then can the water have acquired energy numerically equal to the pressure or equal to 1'031'000 ergs? But when a persistent error admits of such easy refutation, it usually contains a grain of truth. The only way to destroy the pressure-energy complex for good and all is probably to direct greater attention to the *correct* interpretation of Bernouilli's Equation as an energy equation and to urge the general adoption of this interpretation in elementary texts on physics.

According to Bernouilli's Equation

$$E = 1/2\ \varrho v^2 + \varrho g h + p = \text{constant}$$

along a tube of steady flow in a frictionless liquid, where ϱ = density, v = speed, h = height, p = pressure. To deduce this equation from the law of the conservation of energy, consider a section of a tube of flow with ends at A and B, respectively. For every cubic centimeter of the liquid that enters

the section at A, another cubic centimeter leaves it at B. The entering liquid carries into the section kinetic energy $\varrho v^2/2$ and potential energy ϱgh. But it also does work on the liquid ahead of it equal to the pressure times its volume or to p, while at the same time the liquid behind does an equal amount of work upon the cubic centimeter itself in pushing it into the section; thus an amount of energy equal to p is transmitted past A through the entering liquid into the section, in addition to the kinetic and potential energy which is simply carried in. The total energy transferred past A as one cubic centimeter enters the section is thus $E_A = \varrho v_A^2/ + \varrho gh_A + p_A$. At the same time an amount of energy $E = \varrho v_B^2/2 + \varrho gh_B + p_B$ is transferred out of the section at B; while no energy at all is transferred across the sides. The total amount of energy inside the section must, however, remain constant, for the flow is steady. Hence $E_A = E_B$ and Bernouilli's Principle follows.

This deduction brings out the true meaning of the quantity E that is constant along a tube of flow; it represents, not the energy that is stored in each unit volume of the liquid and carried along with it, but rather the total amount of energy that is transferred past any point as each unit volume of the liquid moves past that point. The first two terms in the expression for E represent what we may call a convection current of energy, in which the energy is simply carried along by moving matter. The last term, p, then represents an additional current of energy that is transmitted through the liquid.

If we wish, we can imagine the transmission current of energy, represented by p, to arise from a streaming through the liquid of the energy of compression. The latter energy is never quite zero, but it is always small, and so we shall have to suppose it to move enormously faster than the liquid. A similar current of energy flows along a moving belt, only there the energy moves in one direction while the matter through which it streams is moving in the opposite direction.

In gases the energy of compression need not move so fast in order to account for the transmitted stream of energy, but in this case the energy of compression contributes appreciably to the convection current as well.

This view of the Bernouilli Equation would seem to be just as useful and suggestive as any other, and it seems quite simple enough for presentation in a freshman text. As a matter of fact, examination of a number of elementary engineering books shows that most of the ideas here presented are actually to be found in one or two of those!

E. H. KENNARD

CORNELL UNIVERSITY

CAMPBELL'S DEFINITIVE UNITS

REFERRING to the paper of Dr. George A. Campbell, "A system of 'definitive units' proposed for universal use," published in the issue of SCIENCE for April 3, 1925, the writer realizes that there are many advocates of alternative universal systems of units and is therefore hesitant about entering the lists. It would appear, however, that two modifications of Dr. Campbell's proposal would be of great assistance in the practical introduction of such a system of definitive units. These are:

The retention of the C.G.S. unit of length, the centimeter, instead of the meter; and the use of the true ohm (or "practical" ohm, as Dr. Campbell calls it) instead of the international ohm. These modifications are independent of one another, and will be considered separately below.

USE OF THE CENTIMETER

It is believed that in scientific and engineering work a unit, such as the centimeter, which is smaller than most pieces of apparatus, is more convenient than the meter. It is already in such wide use and has been the basis of so many physical data that a great saving in labor and mental effort would be occasioned if it were retained. The consequence of its retention would be that the unit of force would become 10^7 dynes and the unit of mass would be 10^7 grams. This unit of force has been used in certain[1] texts for a number of years. Being approximately equal to 22.5 lb., this unit is fully as convenient as the value 10^5 dynes proposed by Dr. Campbell, which is approximately equal to 0.225 lb. The writer recognizes that the corresponding unit of mass, 10 metric tons, is not so convenient as the kilogram, but in this connection it should be pointed out that mass in its direct aspect as a measure of inertia enters into relatively few practical and scientific calculations. Mass as a measure of the quantity of matter—that is, mass from the chemist's point of view—is a distinct idea and can continue to be measured in grams or kilograms with little confusion. These latter units of mass may be considered as derived from the large unit by the factors 10^{-7} and 10^{-4}, in much the same way that the customary electrical unit, the microfarad, is derived from the farad by the factor 10^{-6}. All electrical engineers are quite reconciled to the fact that the farad is an enormous unit and are not con-

[1] See Karapetoff, "The Electric Circuit" (1912), p. 217: "*Force ought to be measured in joules per centimeter length,* to avoid the old multiplier. Such a unit is equal to about 10.2 kg. and could be properly called the *joulcen* (= 10^7 dynes)."

fused by the use of the microfarad with its numerical factor of 10^6. As a matter of fact, the kilogram itself is too large for convenience in most scientific work. Both Dr. Campbell's proposal and that of the writer lose what was considered an advantage of the C.G.S. system, that the density of water is approximately equal to unity; so there is no choice on this point. A great convenience of the writer's proposal is that energy, power, force, mass and other quantities directly derived from them all have units larger than the C.G.S. units by the same factor 10^7. This would result in great convenience in referring to existing tables of physical data, since the reader would only have to decide whether to introduce this single factor; whereas with Dr. Campbell's proposal factors of 10^{-2}, 10^{-3}, 10^{-5} and 10^{-7} are given in his Table I, and other factors would enter with subordinate quantities, such as pressure and density. It is believed by the writer that these conveniences far outweigh the inconvenience of a large unit of mass.

USE OF THE TRUE OHM

Dr. Campbell's proposal to use the international ohm, coupled with the use of the mechanical watt, requires many of the electrical quantities to be expressed in units which have never heretofore been employed. While it is true that these units differ to a very slight degree from either the international units or the true (practical) units, nevertheless it is felt that the results would be decidedly confusing. The writer's proposal is to use the true practical electrical units throughout, which is consistent with the mechanical watt. These units are all related to the C.G.S. electromagnetic units by factors which are exactly powers of 10; so that conversion from the C.G.S. electromagnetic system would be greatly facilitated. For engineering purposes, of course, the differences between the international electrical units, the practical electrical units and the electrical units proposed by Dr. Campbell are insignificant.

The units proposed by the writer seem to require a minimum of change from existing practice and yet to have the broad advantages of definitive units as expressed by Dr. Campbell. With the exceptions of the units for force and mass and their derivatives, these units are all in wide use at present. The complete system has for several years been employed by the writer in his electrical engineering classes[2] and for his own computation in fields where electrical and mechanical quantities continually occur together in a variety of ways.

In the writer's opinion, the most important consideration in the introduction of a system of definitive units, assuming the units to be consistent and of *reasonable* magnitudes, lies in *the convenience of the transition from present practice.* The system proposed permits of a gradual adoption of the few new units, as fast as their advantageous features become appreciated; whereas Dr. Campbell's proposed system requires more radical changes.

[2] See L. A. Hazeltine, "Electrical Engineering," The Macmillan Company (1924).

L. A. HAZELTINE

STEVENS INSTITUTE OF TECHNOLOGY

TIME MEASUREMENTS

THE fact that a watch keeps correct time over a period of twenty-four hours is not a sufficient indication of its accuracy in the measurement of short time intervals where the second hand is used. A slight misplacement of the watch dial may cause the pivot of the second hand to be located "off center," thus causing an error of as much as two seconds in measuring an interval of twenty, or twenty-five seconds. Readings on one half of the dial will be too short and those on the other half correspondingly too long.

A similar source of error may be looked for in any dial-reading instrument where particular care has not been taken in fixing the dial position.

RALPH G. DEMAREE

PASADENA, CALIFORNIA

ARTIFICIAL CULTIVATION OF FREE-LIVING NEMATODES

IN SCIENCE, N. S. Vol. 60, No. 1548 (Aug. 29, 1924), pp. 203–204, under the above title, Asa C. Chandler describes a method dependent on the standard culture-methods of bacteriology. So far as developed, this method does not apparently differ from that described by me in the *Trans. Amer. Mic. Soc.*, Vol. 24, pp. 89–102, 1 pl., 1903.

HAVEN METCALF

BUREAU OF PLANT INDUSTRY

SCIENTIFIC BOOKS

The Story of Early Chemistry. By JOHN MAXSON STILLMAN, late professor emeritus of chemistry, Stanford University, xiii + 566 pages, $5\frac{1}{2} \times 8\frac{1}{2}$ inches. D. Appleton and Co., New York, 1924, Price $4.00.

THE amiable author of this scholarly volume (whose recent death was lamented by a host of friends) has long been known as a contributor to the history of medieval chemistry—more particularly of that transitional Paracelsian epoch which was contemporary with various other great movements of exploration, renaissance and reform. It was only natural, therefore,

that Professor Stillman in his present "Story of Early Chemistry" should focus the reader's attention upon Paracelsus as the dominant figure in chemistry before the foundation of the modern science by Lavoisier. The historian's estimate of the relative importance of personages or events is indicated by the amount of space which he gives to their consideration and if this be our standard the following series will indicate the comparative stress which Professor Stillman has placed upon the life and work of a few names in early chemistry—Boerhaave (2 pages), Glauber (4), Helmont (5), Zosimus (7), Cavendish (7), Scheele (8), Albertus Magnus (9), Agricola (10), Boyle (12), Roger Bacon (15), Priestley (15), Paracelsus (19), Lavoisier (25). While there may well be an objection, from our present viewpoint, to the historian of chemistry giving as much attention to Zosimus as to Cavendish, or to Roger Bacon as to Priestley, it must be remembered, as Professor Stillman so clearly indicates, that personal influence can not always be measured by the number of original discoveries.

The history of chemistry may be presented from either the descriptive, biographical, philosophical or literary points of approach. The first of these treatments will describe the important discoveries of chemistry, the second will depict its leading personalities, the third will unfold the development of its basic principles, and the fourth will review its documentary sources of information. The first two of these methods will appeal to the young student, while the last two will attract only persons of mature mind. While sharing somewhat in all these choices of treatment it is principally to the fourth, or literary, type of history that the present "Story of Early Chemistry" belongs. Professor Stillman, following the lead of Kopp, Lippmann, Sudhoff, Berthelot and other foreign investigators, makes a very critical examination of the original records. The authenticity of the chemical texts ascribed to Democritus, Aristotle, Geber, Avicenna, Lully, Basil Valentine, Paracelsus and other early writers is considered more exhaustively by him than by any other writer in English. Without showing the polemical and nationalistic temper of certain European historical scholars he has given a well-balanced estimate of the various conflicting opinions.

In a volume which deals so largely with questions of authorship, much of the material that would be considered by historians of other schools must necessarily be omitted. We may pardon, therefore, in Professor Stillman's volume the omission of any reference to the Pneumatika of the Greek mechanician Hero (the precursor of the pneumatic philosophers named in Chapter xii) or to the discovery of the principle of specific gravity by the Greek geometer Archimedes—the most important contribution to the methods for studying the properties of matter that was made in ancient times. In the apparatus described by Hero and in the method of research devised by Archimedes the alchemists unknowingly possessed an infallible means for determining the character of their fictitious gold, and had they only applied this knowledge the world might have been spared that colossal waste of effort which played so long and so large a part in the story of early chemistry.

Professor Stillman passed away before the first proofs of his book were received from the publisher. This was doubly unfortunate, for had his life been spared a few months longer he might have been able before the final printing to round out his rather incomplete treatment of Arabian chemistry by citations from the important recently published "Arabische Alchemisten" by Julius Ruska. He would also have been enabled to devote that attention to proofreading and indexing which an author of Professor Stillman's meticulous care could only give. The book in consequence contains a considerable number of typographical errors, such as pennance (107), Euripedes (131), notorius (355), and many others. The nouns of German book titles are not capitalized and the endings os and us are used indiscriminately for Greek proper names. In the bibliography the Papyrus Graecus Holmiensis is incorrectly listed as a work of Bernard Palissy. Certain slips of composition would also undoubtedly have been detected by Professor Stillman in the proofreading, such as the statement (p. 136) that the name Chemeia was probably "derived from the *Greek* word chemi signifying black," where *Egyptian* was no doubt intended. Such errors as these, however, are of minor significance in comparison with the general excellence of the volume as a whole.

"The Story of Early Chemistry" is told by Professor Stillman in a particularly pleasing and interesting way. He unfolds before his readers a great drama of ideas in which the successive followers of Hermes, Paracelsus and Stahl are shown hopelessly groping for centuries in the dark until a final burst of light is shed upon the scene by the efforts of Lavoisier.

The many friends of Professor Stillman will appreciate the brief biographical sketch which has been added to the volume as a foreword by Professor S. W. Young, who gives a most delightful picture of the personality and many-sided activities of his departed colleague.

C. A. BROWNE

BUREAU OF CHEMISTRY,
WASHINGTON, D. C.

SPECIAL ARTICLES

A NUTRITIONAL STUDY UPON A FUNGUS ENZYME[1]

POSSIBILITIES in a comparatively uninvestigated field of nutrition have been suggested by the feeding of a vegetable fungus enzymic material called protozyme to growing chicks in a preliminary test at the New Jersey Agricultural Experiment Station. Over a thousand Leghorn chicks of both sexes were used in the investigation for a period of seven weeks, after which the males were eliminated. The test has now continued for a period of twenty weeks. The birds in question are divided into five groups. All receive a normal scratch mixture daily of cracked cereal grains and a ground mash mixture of bran, middlings and corn meal. All have free access to liquid skim milk. The enzymic material is incorporated in the mash mixture as follows: 5 per cent. of the weight of the mash in Group 1, 3 per cent. in Group 2, 2 per cent. in Group 3, 1 per cent. in Group 4 and none in Group 5. Group 5, consuming no accessory enzymic material, acts as a check upon the other four groups.

During the twenty-weeks' feeding in every instance the chicks consuming the enzymic material have manifested a more rapid growth than those not consuming it. The following table indicates the feed consumed and growth attained.

SUMMARY OF GROWTH AND FEED CONSUMPTION UPON LEGHORN FEMALES CONSUMING DIFFERENT AMOUNTS OF FUNGUS ENZYMIC MATERIAL—END OF TWENTIETH WEEK OF AGE

Amount of fungus enzymic material in mash	Number of chicks	Mean weight lbs.	Mean total grain consumption lbs	Mean total mash consumption lbs.
5 per cent.	100	3.24	7.65	8.31
3 per cent.	100	3.03	7.67	8.31
2 per cent.	100	2.89	7.68	8.27
1 per cent.	100	2.80	7.70	8.21
None	95	2.65	7.77	7.73

Duplicate qualitative tests upon material taken from the crop and gizzard at the end of the sixth week of age indicated increased starch and protein digestion in individuals consuming the enzymic material over those not consuming it.

GEORGE W. HERVEY

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

[1] Paper No. 244 of the journal series New Jersey Agricultural Experiment Stations, Department of Poultry Husbandry.

GASTRIC TRANSPLANTATION

THE study of gastric motility as ordinarily carried out is attended with many technical difficulties. It was conceived that it might be possible materially to reduce these difficulties by transplanting the stomach to a subcutaneous locus so that it could be viewed directly from the outside. Whether the animal could survive such an operation, maintain normal nutrition and gastric movements was the crux of the problem.

The problem was attacked in the following way, using young albino rats. The animals were given no food for twenty-four hours before the operation and none for twenty-four hours after. A median longitudinal incision of 2 cm was made through the abdominal wall along the linea alba. The stomach was lifted through this opening and the abdominal muscles sutured together beneath it, but leaving openings sufficient to transmit the esophagus and the pylorus. These structures were anchored to the abdominal wall by two stay sutures each. Then the integument was dissected back from the muscle laterally on each side to form a pouch for the stomach. The cut edges of the skin were brought together and held by continuous sutures closing the incision. Thus the stomach was covered on the outside by skin and lay between the skin and the abdominal muscles. In two weeks the incision was healed and the animal ready to be observed. Of ten animals first subjected to the operation five lived. Later five more animals were operated on and all lived for considerable periods. Three are alive and apparently normal at the end of nine months. These have been studied with care. They show a normal weight graph, normal appetite and apparently normal peristalsis. They have at no time shown signs of esophageal or pyloric stasis.

The contour of the stomach and its contraction waves can readily be seen through the skin. To permit study of these contractions the rat is placed in a small glass-bottomed cage. This cage is suspended above a bench upon which the observer reclines.

At present the writer is working on the question of the relation between gastric contractions and muscular activity. The observation cage is suspended from one end of a Fitz pneumograph (Porter type) which is connected through rubber tubing with a tambour (Durrant method).[1] This is a highly sensitive method of detecting movements of the animal. For example, the rat's nibbling a grain of corn sets the system into marked oscillations. The tambour is adjusted to write on a revolving extension kymograph drum. Below the tambour lever is adjusted a signal magnet with simple key in circuit and a chronograph.

[1] Durrant, *Am. J. Physiol.* (Balt.), 1924, *70,* 344.

A point is marked on the skin about half way between the cardiac and pyloric ends of the stomach. Whenever a wave is seen passing this point the simple key is closed, thus recording it on the drum. A single stroke represents a shallow wave, two strokes a medium and three strokes a deep wave. When the animal shifts its position so as to obscure the view the signal key is depressed until a readjustment of the posture is secured.

A fairly high correlation between muscular movements and gastric peristalsis as postulated by Richter[2] is evident. Frequently in the quiescent animal gastric contractions become shallow or apparently entirely cease. These suddenly become deeper, whereupon the animal at once arouses to activity and carries out sundry movements, such as washing or scratching. More frequently, however, it has been observed that muscular activity immediately precedes rather than follows augmented gastric motility.

A detailed account of the observation will be published later.

MYRON H. POWELSON
DEPARTMENT OF PHYSIOLOGY
OHIO STATE UNIVERSITY

THE IOWA ACADEMY OF SCIENCE

THE thirty-ninth annual meeting of the Iowa Academy of Science was held at the Iowa State Teachers College, Cedar Falls, Iowa, on May 1 and 2, 1925.

Officers were elected as follows: *President,* R. I. Cratty, State College; *vice-president,* C. E. Seashore, State University; *secretary,* P. S. Helmick, Drake University; *treasurer,* A. O. Thomas, State University; *editor,* Willis DeRyke, State University; *representative to American Association for the Advancement of Science,* D. W. Morehouse, Drake University.

The following papers were presented:

BACTERIOLOGY

(Iowa State College Branch, Society of American Bacteriologists.)

Section Chairman, Max Levine, State College, Ames.

Some notes on trickling filters in the purification of creamery wastes: MAX LEVINE.

Bacterial decomposition of sugars and acids: JOHN H. WATKINS.

Yeasts in bottled carbonated beverages: W. R. TURNER.

Effect of reaction on the growth of yeasts: J. C. WELDIN.

The development of metallic flavor in buttermilk: M. P. BAKER and B. W. HAMMER.

The influence of carbon dioxide on the quality and keeping qualities of butter and ice cream: F. F. SHERWOOD.

The production of hydrogen sulphide by bacteria: F. W. MULSOW and FRED S. PAINE.

Unsolved problems related to the inoculation of legumes: LEWIS W. ERDMAN.

Some bacteriological activities in manures: A. J. ENGLEHORN.

Bacteriological activities in an orchard soil: R. H. WALKER.

Do we have "niter spots" forming in Iowa? PAUL EMERSON and DON S. GRAY.

Teaching the elementary course in bacteriology: R. E. BUCHANAN.

BOTANY

Section Chairman, G. W. Martin, State University, Iowa City.

Genetic correlation between fruit size and color in the tomato: E. W. LINSTROM.

Some Aminitas from eastern Iowa: G. W. MARTIN.

Notes on Iowa fungi—1924: G. W. MARTIN.

Some soil and moisture relationships of sweet gum and river birch in southern Maryland: FRED B. TRENK.

The occurrence of hickories in Iowa in relation to soil types: FRED B. TRENK.

The formation of root hairs in water: CLIFFORD H. FARR.

Ceratophyllum demersum in West Okoboji lake: EDWARD N. JONES.

Microsporogenesis in Cucurbita maxima: EDWARD F. CASTETTER.

Chromosome studies of Zea Mays L.: R. G. REEVES.

An abortive lily anther: CHARLES A. HOFFMAN.

Some wound responses of citrus leaves: ROBERT B. WYLIE.

Culture studies on Psilocybe coprophila: KATHRYN GILMORE.

A partial list of the parasitic Ascomycetes of Iowa: JOSEPH C. GILMAN.

A trip in the Iron Range Country: L. H. PAMMEL.

Some notes on the flora of Forest and Florence counties, Wisconsin, and Iron county, Michigan: L. H. PAMMEL.

Germination of some pines and other trees: L. H. PAMMEL and C. M. KING.

Our native plants (an article appearing in the Iowa Farmer and Horticulturist, Vol. 1, No. 7, Nov., 1853): L. H. PAMMEL.

A provisional list of the species of Septoria in Iowa: B. N. UPPAL.

A tree census of Mount Pleasant, Iowa: H. E. JAQUES.

The physiographic ecology of a Wisconsin drift lake: LOIS A. CATLIN and ADA HAYDEN.

Iowa in the botanical manuals: B. SHIMEK.

Deforestation and stream pollution: B. SHIMEK.

Some noteworthy Iowa fungi of 1925: GUY WEST WILSON.

CHEMISTRY

(Iowa and Ames Sections, American Chemical Society.)

[2] Richter, Comp. Psychol. Monogr., 1922, *1*, Serial No. 2, September.

Section Chairman, George Coleman, State University, Iowa City.

Nutritive value of powdered milk together with observations for a new vitamine for reproduction: L. T. ANDEREGG and V. E. NELSON.

Cod liver oil as a source of vitamine A: GEORGIAN ADAMS, L. T. ANDEREGG and V. E. NELSON.

Some dolomites: N. KNIGHT.

The need of computation rules in chemical calculations: STEPHEN POPOFF.

The action of certain oxidizing agents on sulfite and its determination: W. S. HENDRIXSON.

Microstructure of paint films: H. L. MAXWELL.

Condensations with alkylene bromides: H. F. LEWIS and CHARLES FORDYCE.

Bromination of methyl-4 acetylaminophenyl ketone: L. CHARLES RAIFORD and H. L. DAVIS.

Vanadium oxytrichloride as a solvent: F. E. BROWN and J. E. SNYDER.

Conductance in liquid hydrogen sulfide solutions: G. N. QUAM and J. A. WILKINSON.

The determination of the equilibrium constant for the reaction, $2SO_2 = SO_3 + S$, at the temperature of boiling sulfur: W. R. SKIDMORE and JACOB CORNOG.

The effect of temperature and solvent on nitrogen trichloride additions: acetylene hydrocarbons and nitrogen trichloride: G. H. COLEMAN, C. N. OWENS and J. A. RODRIGUEZ.

The reaction of nitrogen trichloride with various types of olefine hydrocarbons: G. H. COLEMAN, A. W. CAMPBELL and G. M. MELLINS.

Determination of total acidity in the presence of substances which make indicators or hydrogen electrodes useless: STEPHEN POPOFF and M. J. MCHENRY.

Decomposition of hydrogen bromide by the silent electric discharge: ANSON HAYES and J. J. CANFIELD.

Scale formations in water cooling systems of refrigerating machines: EDWARD BARTOW.

The preparation of pure octane: H. F. LEWIS and G. ROBERT YOHE.

The preparation of pure di-isobutyl: H. F. LEWIS and J. WESLEY FLEMING.

The mechanism of the reaction between nitro compounds and organo magnesium halides: HENRY GILMAN and ROY MCCRACKEN.

A comparison of the food values of Iowa winter apples: PAUL W. FRISK.

Systems formed by certain inorganic compounds with liquid sulfur dioxide: HOWARD T. BEACH with P. A. BOND.

Vitamine A and longevity: J. H. HANSBROUGH, V. E. NELSON and E. I. FULMER.

GEOLOGY

Section Chairman, Glenn Dillé, Coe College, Cedar Rapids.

A Ceraurus pleurexanthemus Green, from McGregor: A. O. THOMAS.

Notes on some Paleozoic Echinoderms: A. O. THOMAS.

An unusual oolite near Hayfield, Frederick county, Virginia: A. S. FURCRON.

The Mississippian-Pennsylvanian and Pennsylvanian-Pleistocene unconformities in Lucas county, Iowa: A. D. LUGN.

Some large glacial boulders in Des Moines county, Iowa: A. L. LUGN.

A general description and history of the Macbride collection of fossil Cycads at the State University of Iowa: GRACE ELIZABETH NEBRO.

Glacial geology of Story county, Iowa: JOHN E. SMITH.

Deep well at Morning Sun: J. M. LINDLEY.

The Cambrian of the Mauston Quadrangle, Wisconsin: WILLIAM F. V. LEICHT.

Stratigraphic value of volcanic ash: CHARLES KEYES.

New method of precise geological correlation: CHARLES KEYES.

Stone axes from Adel: JAMES H. LEES.

The occurrence of caliche in Oklahoma: JOHN T. LONSDALE.

Physical features of the Hawaiian islands: CHESTER K. WENTWORTH.

The Indians of the Fort Apache region: ALBERT B. REAGAN.

Sedimentary processes on volcanic islands: CHESTER K. WENTWORTH.

Translocation of Iowa's Siouan mountains: CHARLES KEYES.

Moulding sand in eastern Iowa: JOHN E. SMITH.

Climatichnites fosteri from the Mauston Quadrangle, Wisconsin: WILLIAM F. V. LEICHT.

The Deep Creek reservation and its Indians: ALBERT REAGAN.

MATHEMATICS

(Iowa Section, Mathematical Association of America.)

Section Chairman, Ira S. Condit, State Teachers College, Cedar Falls.

Experiments with small numbers of observations: G. W. SNEDECOR.

On the numerical effect of certain variations in the assumptions relating to the distribution of unknown probabilities in the inversion of the Bernoulli theorem: H. L. RIETZ.

Notes on algebraic deficiencies: J. V. MCKELVEY.

The locus of the centers of the conics through four real points: H. K. HUGHES.

The members of the system of conics passing through four real points: H. K. HUGHES.

An application of Rolle's theorem to functions of finite genus: MARIAN E. DANIELLS.

Address by the retiring chairman: *The determination of mathematical ability:* E. R. SMITH.

Sufficient conditions for the periodicity of the solutions of certain functional equations: W. H. WILSON.

The rule of double position: J. S. TURNER.

Some properties of prolate spheroids: J. S. TURNER.

On a line similar to Simpson's line: ROSCOE WOODS.

Two theorems on annuities: JOHN F. REILLY.